

# Research and Development for National Defense\*

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**Summary**—This article describes the duties, composition, and major operations of the Research and Development Board of the Department of Defense. This Board is the agency charged with co-ordination of the research and development programs carried on by the Army, Navy, and Air Force. In the article, particular attention is given to the activities and scope of the RDB's Committee on Electronics and to new developments, both military and nonmilitary, in the field of electronics.

The author uses examples to illustrate the point that the application of science and technology to warfare is not a recent development. He warns against easy acceptance of the idea that new weapons and techniques will provide the answer to all the problems involved in our national defense, although the principal aim of the RDB and the research and development agencies of the armed forces is to provide our fighting men with the best possible weapons.

## RESEARCH AND DEVELOPMENT BOARD

BEFORE THE DAWN of history, man turned periodically to warfare with his neighbor, and from the first battle with clubs down to the present time there has been a constant race for new weapons and countermeasures. Furthermore, the application of science and technology to warfare is not new. We think of biological warfare, for example, as a revolutionary and untried weapon, but early historical accounts tell of the ancients catapulting the bodies of their dead over the walls of besieged cities to spread the disease which they knew would follow, although they did not know why. And thirteen centuries later, Genghis Khan, famous ruler of the Mongols, used chemicals in the form of huge balls of pitch and sulfur thrown at the enemy to produce a combination of screening smoke, choking fumes, and incendiary effects, thus ushering in the dread chemical warfare that was used with such telling effect by the Germans in World War I. A third example is the machine gun. It has been generally supposed that this weapon developed from the Gatling gun, invented during the American Civil War; yet a device embodying the principle of the modern machine gun was invented by the Greek engineer Dionysius of Alexandria in the third century B.C. This weapon fired a succession of arrows supplied by a magazine or hopper, and at fairly close ranges gave a fire power unchallenged by any other light ordnance piece until the invention of the longbow in the late Middle Ages.

It is therefore not unusual that the race for scientific weapons continues—it has had a long and eventful history—but it is startling to realize that today the Department of Defense and the Atomic Energy Commission engage the services of almost two thirds of the nation's scientists and engineers and that the program for military preparedness represents an annual expenditure of one and one-half billion dollars.

The size of the military research and development effort is not only startling, but sobering and thought-provoking. We are confronted by the fact that the greatest

portion of the creative thinking and effort of our scientists and engineers is, of necessity, being concentrated on weapons, devices, and techniques of warfare, and on countermeasures. Not only is the country, as a whole, spending a vastly larger sum on research and development than ever in its history, but most of this is going for military purposes.

Obviously, this phenomenon is having a profound effect on our culture. There have been diversions and disruptions in the fields of teaching and of academic and industrial research, and basic research, the lifeblood of scientific progress, has been subordinated to applied research and to development. As Dr. Vannevar Bush stated in the most recent report of the Carnegie Institution of Washington, there may be grave dangers inherent in increased governmental regimentation of scientific research, although there appears to be no alternative method of administration.

It is not my intent, however, to contemplate philosophically the possible effects of these things, no matter how strongly we may feel about them. We must adjust ourselves to the realities of the times if we are to accomplish the enormous tasks ahead of us. We want to make sure that if our men are called to the defense of the nation again they will be equipped as well as it is possible to equip them. The responsibility of the RDB lies in this area, our primary duty being to guide military research and development toward the achievement of maximum weapons effectiveness for our Armed Forces. To see how the RDB performs this vital function, let us first examine briefly the structure and responsibilities of the Board and then consider the work of the Committee on Electronics, with specific examples of how research and development are related to military plans and strategy.

## Duties of the Board

In the preceding paragraph I have set forth the over-all mission of the RDB. More specifically, the Board is directed by law:

- (1) to prepare a complete and integrated plan of research and development for military purposes;
- (2) to co-ordinate research and development among the military departments and allocate responsibility for joint programs; and
- (3) to consider the interaction of research and development and strategy, and to advise the Joint Chiefs of Staff in connection therewith.

I want to emphasize here that the actual research and development work is done by the Services themselves; the RDB is not an operating organization. Part of the Services' research is carried out in their own installations, but most of it is handled on contract with industry and academic institutions. The RDB supplies leadership and integration of this total program to assure that the available money and talent are expended on the most vital areas and not wasted on less essential things.

## Composition of the RDB

The Board proper is composed of a civilian chairman and two representatives from each of the Military Departments. Mr. Walter G. Whitman, currently on leave from the Massachusetts Institute of Technology, where he is head of the Chemical Engineering Department, is chairman. The Army representatives are Assistant Secretary Earl D. Johnson and Major General Kenneth D. Nichols, Chief of Research and Development. Representing the Navy are the Honorable John F. Floberg, Assistant Secretary for Air, and Rear Admiral M. E. Curts, Assistant Chief of Naval Operations (Readiness). The Air Force members are Under Secretary Roswell L. Gilpatric and Major General Laurence C. Craigie, Deputy Chief of Staff, Development. The seven-man Board makes broad policy decisions affecting the entire military research and development program.

The Board itself is a part-time group, meeting, ordinarily, about once a month. Serving under the Board and preparing material for its consideration is a staff organization consisting of approximately 300 civilian and military personnel and a committee and panel organization of 2,400 part-time military and civilian experts. The civilian experts, most of whom serve without compensation, are drawn from industry, the universities, and other government agencies. All are recognized leaders and authorities in their fields of science or engineering.

Each of the fifteen committees of the Board has cognizance over a specific field or certain type weapon. At present we have committees on aeronautics, atomic energy, biological warfare, chemical warfare, electronics, equipment and supplies, fuels and lubricants, geophysics and geography, guided missiles, human resources, materials, medical sciences, navigation, ordnance, and technical information.

The area of responsibility of a committee is normally subdivided and assigned to panels. As an example of a structure of this type, Fig. 1 shows the panels of the Committee on Electronics.

Through the occasional rotation of committee and panel members, new ideas and viewpoints are introduced while, at the same time, continuity of operations is preserved. The committees and panels meet six or eight times a year, as required by their various duties. Meetings are held at Washington or at points where military research work is in progress. Each committee is served by a full-time staff of technical experts.

The duties of the committees are several: They review, in detail, the military research and development program in their assigned field and make recommendations concerning modifications of the program. They periodically assess the state of weapons development in their field. A particularly valuable product of their activity lies in providing an effective forum for the cross exchange of information and ideas. Representatives

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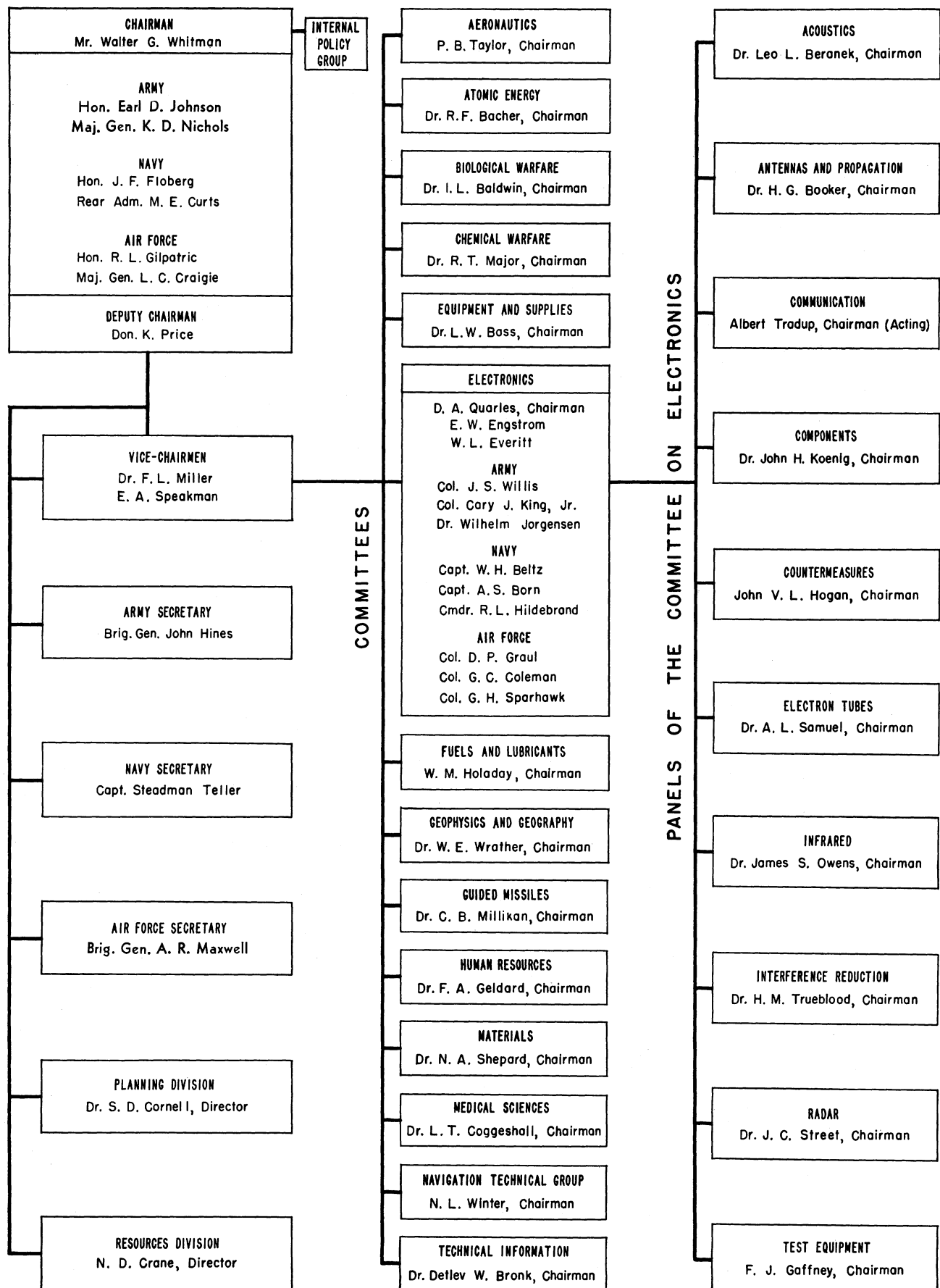


Fig. 1—Research and Development Board, Department of Defense.

from the Services, which actually administer the research, report their plans and the progress of their work, and the men from outside the Departments ask questions, offer advice, and make other valuable contributions toward the improvement of the programs. The committees and panels therefore provide a vital connection between the military research and development program, on the one hand, and industry, the universities, and other government agencies on the other. Many important problems are solved at the committee or panel level.

#### *Committee on Electronics*

A brief explanation of the activities and scope of the RDB's Committee on Electronics will probably be of particular interest to readers of this publication. From a standpoint of expenditures, the field of electronics comprises between 20 and 25 per cent of the total military research and development program, or about 250 million dollars. This includes programs under the sole cognizance of the Committee on Electronics and, in addition, those co-ordinated jointly with other committees, such as Guided Missiles, Aeronautics, and Ordnance.

Under the terms of its directive, which is similar in scope and intent to those of other RDB committees, the principal objectives of the Committee on Electronics are co-ordination, guidance, and integration of the Military Departments' efforts toward developing, through electronics research, the best possible weapons and supporting systems for the Armed Forces of the United States.

The Committee's area of interest includes about 3,100 projects which lie in widely divergent technical fields. This poses difficult problems of Committee administration, and the Committee has accordingly divided its field among ten panels encompassing more homogenous areas. These are radar, communication, electronic countermeasures, acoustics (sonar), infrared, antennas and propagation, components, electron tubes, test equipment, and interference reduction.

Each of these panels consists of a civilian chairman and one or more civilian members, plus a member representing each of the Military Departments. Several of the committee and panel experts are members of the Institute of Radio Engineers, and we are happy to have the resources of this excellent organization as a fountainhead of competent and experienced electronics specialists to serve as consultants and replacements for members.

Periodically, the members of the committee and panels visit electronics installations and contractors engaged in development throughout the country in order to acquaint themselves as fully as possible with work being done in the field.

#### *Main Operations of RDB*

The RDB maintains close working relationships with other agencies of the Department of Defense, such as the Joint Chiefs of Staff, the Weapons Systems Evaluation Group, and the Munitions Board, and also with the Central Intelligence Agency, Atomic Energy Commission, Na-

tional Science Foundation, and National Academy of Sciences.

In order for the Board and its committees to evaluate scientific programs, it is necessary to have some idea of the operational and strategic needs of the Military Departments. This information is supplied by the Joint Chiefs of Staff in the form of strategic plans and military requirements which are used by the committees of the Board in their examination of scientific programs. In this way each important area of research is studied in relation to military needs in order to assure that new weapons and techniques meet the requirements of the Armed Forces.

The Board, on the other hand, advises the Joint Chiefs periodically with reference to new weapons and countermeasures. This information is in the form of reports, or technical estimates, of what new weapons and techniques will result from research, and an estimate of the date when these new weapons will become available. Promoting an even closer tie between the two agencies, the chairman of RDB attends meetings of Joint Chiefs of Staff at which research and development matters are discussed.

In addition, the Board, through its committees, also provides technical guidance to Army, Navy, and Air Force to assist them in formulation of research programs.

The Weapons Systems Evaluation Group, sponsored jointly by the JCS and the RDB, performs operations research in certain broad areas, such as land combat.

The RDB advises the Munitions Board of new developments that will require critical and strategic materials so that the Munitions Board can anticipate the need for such materials in production. On the other hand, the Munitions Board informs the RDB as to those materials which are in short supply and where it is necessary that research effort on substitutes be increased.

Information on the military research and development activities of other countries is, of course, of interest to us, and the Central Intelligence Agency supplies us with pertinent facts on various areas. This information is used for comparative purposes to assess our effort in general and to aid in a prediction of our weapons' performance against any which other countries may now have under development. As is well known, the supply of technical information from certain countries is very tight; the Iron Curtain makes such intelligence most difficult to obtain.

With reference to the National Academy of Sciences, we find that they have certain groups and specialists in various technical fields that can be utilized in the solution of important problems. For example, with the strong backing of the RDB, the Minerals and Metals Advisory Board<sup>1</sup> was established, less than a year ago, under the National Academy of Sciences to undertake the responsibility for examining programs and making recommendations in this field. The MMAB has recently submitted a number of excellent reports, including one on titanium, a new metal which has great significance to American industry.

#### *New Developments—Electronics*

Now, after my discussion of the organization of the research program, I should like to mention a few results of that program.

<sup>1</sup> Formerly, Metallurgical Advisory Board.

Everyone is aware of the importance of radar in bringing World War II to a successful conclusion and of its many commercial applications today in the navigation of both ships and aircraft. The military program is aimed at increasing the range on small targets, such as aircraft and guided missiles, and at developing high-powered transmitters that will enable us to pick out and track enemy missiles or bombers. Electronics has so many commercial applications that it is only natural that we find it an integral part of most weapons. The electronic equipment of one of our new planes accounts for 40 per cent of its cost. The electronic equipment of one of our large bombers contains some 1,200 vacuum tubes. In fact, we look upon certain type aircraft as flying laboratories, with all their intricate systems for control of the plane, navigation, communication, gun firing, and radar location of targets. As a result of this wide application of electronics we have encountered many new problems that must be solved in order to assure reliable weapons. One urgent problem concerns the development of more reliable electron tubes, but we think that the development of the transistor, largely through the efforts of Bell Telephone Laboratories, offers great promise as a possible solution.

The field of communication is another important branch of electronics research. Recent developments sponsored by the Signal Corps make it possible to send almost 100 voice messages or several television or radar presentations simultaneously over one radio channel. This has great significance to our air defense, since it would be necessary, in the event of war, to have high-speed communication links throughout the continent in order to alert our air-defense centers to the approach of enemy planes.

The requirement for effective electronic countermeasures can hardly be overemphasized. You may remember how, in February, 1941, the German naval vessels, *Gneisenau*, *Scharnhorst*, and *Prinz Eugen*, made their escape through the English Channel from Brest. The British had the Channel completely covered by radar, but their signals were so successfully jammed by the Germans that no radar echoes were obtained from the ships. This was the first significant operational use of countermeasures in World War II.

For repelling Allied bomber attacks, the Germans relied in great measure on anti-aircraft artillery—some 15,000 heavy guns controlled by about 3,000 fire-control radars. This presented a formidable obstacle, particularly since our bomber losses at that time were rather high. An Allied countermeasure program was begun in 1944, and the second important operational use of countermeasures occurred late in that year when jammers were installed in our bombers. This operation was most successful in reducing the effectiveness of the German guns.

In World War II our radar-countermeasures units also used small pieces of tinfoil, called "chaff," to produce false signals on enemy radar screens. When a package containing several hundred thousand pieces of this material was dispersed by aircraft the echo produced looked exactly like that of a bomber and frequently diverted the Germans' antiaircraft fire from the real target. Our entire program on counter-

measures continues much of the research aimed at jamming and destroying the usefulness of enemy radio signals. This will enable our planes to operate more freely under radar-directed antiaircraft fire.

I have mentioned the importance of electronic devices as components of aircraft; the effectiveness of guided missiles also depends to a large extent on electronic equipment. Our guided-missile development shows promise of providing weapons which can be launched from the ground against enemy aircraft or missiles and others which can be launched from our own aircraft against various surface targets. Most of these missiles depend upon electronic systems of guidance and are extremely complicated. An important aspect of this program is devoted to preserving flexibility of design so that various type warheads, including atomic warheads, can be carried by these missiles.

#### *Peacetime Applications*

And now, lest I leave the impression that the research and development program is a kind of military Juggernaut under whose wheels peacetime projects will be ruthlessly sacrificed, I should like to emphasize that not all of the money spent for this purpose goes up in the smoke of battle. Military research, no matter how deadly its intent, nearly always produces something with a

humanitarian application. Many would argue, for instance, that the medical and biological aspects of atomic-energy research have already canceled out the havoc wrought at Hiroshima and Nagasaki.

Studies of the action of nitrogen mustards, developed as a toxic chemical agent, reveal their remarkable destructive effect upon white blood cells. These findings suggest the use of the mustards in the treatment of leukemia, and have led to the initiation of studies that have spread to more than 120 clinics, with hundreds of cases under treatment. More recent experiments have indicated that these mustards may also prove effective as a remedy for rheumatoid arthritis and for asthma.

In the field of electronics, many of the manufacturing techniques now being used in the manufacture of picture tubes for television were born of World War II research on cathode-ray tubes used for radar.

#### *No Easy Answers*

With a program of research and development as large as I have described, one might assume that future wars will be fought at great distances where human beings seldom come in contact with each other. We must be careful, however, not to convince ourselves that science will provide an easy answer to all our problems. New and

fantastic weapons may be of some assistance but we must guard against trusting our future entirely to such devices. Great strides have been made and will continue, but I want to stress the fact that no new weapon which we now know anything about will eliminate the need for powerful, well-trained armed forces in the Army, Navy, and Air Force. We will need just as much hard work and unselfish devotion on the part of each individual as we have ever had in the past if our nation and liberties are to survive.

We believe that the RDB has contributed a great deal to the integrating of these programs which I have described, and to an over-all program of military research and development. If the task of co-ordination is not yet all that we should like it to be, at least we can feel that we have helped to bring about a fruitful cross exchange of information. Not only are the services aware of what each other is doing, but through our civilian Committee and Panel members, they are aware of relevant work which is being done by industry and universities.

Our primary aim is to assure our fighting men the superior weapons necessary to overcome the numerical superiority of the Communist forces. And as Secretary Lovett recently said, "We don't have to match the Communists man for man; we aren't going to dance with them."

## Measuring the Mean Power of Varying-Amplitude Complex Audio Waves\*

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**Summary**—A new instrument which is capable of determining and recording, over successive short time intervals, the mean-power level of complex audio waves of rapidly varying amplitude is presented. While designed primarily for research work with speech sounds, where variations of as much as 35 db in level within 1/100 of a second are not uncommon, the unit could be applied to the power-level analysis of any voltage wave varying with components fully within the audio range. The apparatus provides a representation of power level in decibels for the brief phonetic elements of speech or for other similar elements of widely varying amplitude, without confusion of data or ambiguity of interpretation.

#### INTRODUCTION

IN AUDIO-FREQUENCY RESEARCH, where rates of signal-level change up to 3,000 db per second may be encountered, experimenters have needed instrumentation capable of presenting this rapidly varying level accurately enough to permit analysis of power level "fine structure." Values of mean power for short

time intervals would be highly desirable for the analysis of individual phonetic elements in speech transmission studies where audibility and comprehension are being investigated.

Specifically, an instrument for such mean-power studies should meet four requirements: (1) For ac inputs of fixed level the unit output should be constant, showing no variation during individual input cycles. (2) Its output should be independent of input signal wave shape and should read nothing but average power for all complex waves having fixed amplitude components, regardless of phase relation between the components. (3) The value read for power level should follow closely abrupt variations in the signal so that at any instant during intervals of signal change the curve obtained by joining successive "per-input-cycle" values of mean power will be closely represented by the output of the instrument. (Note that transient impulses such as sibilants, lacking a fundamental frequency, must also be represented by some kind of sampling technique). (4) It should present its output in decibels to conveniently represent the wide

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